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ABSTRACT

The purpose of this study was to determine the nature of teachers' implicit in-action mental models about children's minds and learning, as inferred through the ways they teach. The work was based on the theoretical works of D. Schon, L. Shulman, and P. N. Johnson-Laird. Study participants included 24 student, novice, and experienced teachers. All teachers taught the same first-grade arithmetic lesson. Teacher behaviors and the inferred teachers' in-action mental models are described. Findings indicate that teachers have an in-action mental model of children's minds and of how learning takes place in children's minds and that this mental model directs their teaching. This model, which is implicit and intuitive, reflects an understanding of the mind shared by teachers from all three groups. Four implications for teacher education are: (1) the in-action mental model has profound influence on how teachers teach; (2) preservice and inservice teachers understand what is being taught in courses and workshops that relate to children's learning, via their in-action mental model; (3) teachers are not aware they hold this model, and in order for the implicit in-action model to be discussed, it must become explicit; and (4) the tool developed to describe teachers' in-action mental models of children's minds and learning can be used in teacher education both as a diagnostic tool and as a tool for instruction. (Contains seven references.) (ND)

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Teachers' In-action Mental Model of Children's Minds and Learning

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The research reported here informs teacher education, and is located within the framework of theory and research on teachers' cognition (Schon, 1983; Shulman, 1986, 1993). We tested teachers' mental models (Johnson-Laird, 1983) about children's minds and learning. These mental models are implicit. Teachers do not know they hold them.

The work was based mainly on three theoretical sources:

The first is Schon's (1983, 1987) distinction between theories held by professionals. These include theories of practice, espoused theories and in-action theories. We studied professionals' in-action theories which are theories that underlay their actual professional behavior, (for example: when teacher teaches an arithmetic lesson in class). The theories are implicit and the professionals are not aware of them. The professionals in our study are teachers.

The second theoretical source is Shulman's (1986, 1993) classification of types of knowledge which teachers use when teaching. Among them is pedagogical content knowledge. This is the knowledge teachers have about how pupils learn subject matter; For example, what makes material difficult to learn and what the teacher can do to help

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the children overcome these difficulties. We studied teachers' pedagogical content knowledge (Shulman) during actual teaching (Schon).

The third theoretical source was Johnson-Laird' definition of mental models as a cognitive entity which represent the external world. We studied teachers in-action (Schon) mental models (Johnson-Laird) about children's minds and learning and the role of teaching in fostering learning (Shulman).

The main purpose of the study was to determine the nature of teachers' implicit in-action mental models about children's mind and learning, as inferred from actual teaching. Because teachers teach for learning to take place, we can infer their mental models of learning through the ways they teach.

Method

A total of 24 first grade teachers were selected and divided into 3 groups of 8 teachers each, according to their teaching experience:

- * 8 preservice teachers (student teachers).
- * 8 novice teachers (no more than 2 years teaching experience).
- * 8 experienced teachers (at least 7 years teaching experience).

We assumed that there would be differences between the three groups, but because there were neither empirical precedents nor theories which could help us predict where these differences might be, our study had no hypotheses about these groups.

We videotaped an arithmetic lessons given by each teacher on the process of adding two numbers that yield a third number. All teachers taught the same lesson in the normal course of teaching arithmetic, using the same curriculum unit. The teachers introduced adding via Cuisenaire rods, that represent numbers by a combination of color and length. The length of the lessons ranged between 20-30 minutes.

A Categorization System

We developed a two tier category system that allowed us to classify teachers' instructional behaviors and to infer the in-action mental model they hold about children's minds and learning. One of the major problems of constructing a category system of teachers'

instruction is to conceptualize the units of analysis that comprise instruction. This involves deciding what the units are and what constitutes the boundaries of the unit (i.e., where it begins and ends).

The first tier classified teachers' explicit teaching behaviors, and we found they were organized into units that bear resemblance to those described by both Flanders (1970) and Cazden (1988).

The first tier has four units:

- 1) The teachers' and pupils' behaviors; e.g., the teacher asks a question. Each behavior at this level is meaningless. In our study we recorded approximately 11,000 teacher behaviors.
- 2) An event is the combination of several behaviors on the part of teacher and pupils. It is a triad interaction between the teacher and the children; e.g., the teacher asks a question, a pupil answers the question, and the teacher responds to the answer. Behaviors from the first unit gain meaning in the events. We found 12 kinds of events and a total of 2787 events in this study.
3. An episode includes combinations of several events. There are several events of the teacher asks - pupil answers - teacher responds type, where the aim of the episode is for instance, to define the subject being presented. We found 12 types of episodes and a total of 325 episodes in this study.
- 4) A lesson is comprised of a number of episodes, where the lesson has a particular purpose; e.g., introducing the subject matter: addition.

The second tier is inferential and is based on the teachers' behaviors that we observed in the first tier. The units of the second tier comprise the teachers' in-action mental model. These units are:

- 1) Cognitive goals which teachers want their pupils to achieve; e.g., connecting the new material being taught to what is already known. We found 9 types of cognitive goals.
- 2) Cognitive processes which teachers think lead to these cognitive goals; e.g., retrieval of already-learned material from memory. We found 9 types of cognitive processes.

- 3) Basic assumptions about how teaching in a particular way leads to these processes, that in turn, lead to the cognitive goals; e.g., mentioning a prior lesson leads to the retrieval of already-learned material from memory. We found 40 types of basic assumptions.
- 4) The "mother" of all assumptions (meta-assumptions) about learning and teaching; e.g., knowledge is stored; knowledge can be retrieved. We found 10 types of meta assumptions.

These four units, that comprise the teachers' in-action mental model, are inter-related and are related to the teachers' teaching behaviors.

We now present a partial analysis of behaviors by a teacher and some pupils.

The teacher is seated with five first grade youngsters in the classroom, while the other children are doing engaged in an assignment. The children have already been introduced to Cuisenair rods in a prior lesson. In what follows, the numbers that appear in parentheses indicate a behavior. The following occurred in the classroom:

EPISODE 1: USING ALREADY LEARNED KNOWLEDGE

EVENT 1 - Demonstration. The teacher holds up two Cuisenair rods, one whose length is 4 units and one whose length is 2 units. T(Teacher): (1) "I want to present something to you that I am going to build, and tell me what you see". (The teacher puts the two rods together end-to-end) (2) What did I do"? C(Child): (3) "It's adding, adding". C: (4) "Adding". T: (5) "It's an adding problem".

EVENT 2 - Qualifying. T: (6) "Right"? C: (7) "Yes". T: (8) "An adding problem".

EVENT 3 - Clarification. T: (9) "Can someone tell me what kind of problem this is"? C: (10) "We are learning". T: (11) "We are learning, but which numbers"?

EVENT 4 - Directing. T: (12) "Which numbers"? (13) Pay attention to the adding problem". C: (14) "4 and 2". T: (15) "Very good. 4 and 2. Right".

EPISODE 2: EXPANDING AN ARITHMETIC OPERATION

EVENT 1 - Reconstruction. T: (16) "Now, I'd like to ask a question. Let's see who can take the correct rods of the box (that contains rods of different length. Don't do the exercise yet. (17) Here, for this adding exercise I have two rods, right? An adding exercise that's made up of ..."? C: (18) "Two rods". T: (19) "Two rods".

EVENT 2 - Introducing New Material. T: (20) I'd like you to find one rod, but the exact same length as these two rods. (21) Do you understand what I mean "? C: (22) "Yes". T: (23) "Those who understand should do the exercise. Those who don't should wait, should think".

Here we see 23 behaviors on the part of teacher and children. Space considerations do not allow us to analyze each behavior and all 8 units from the two tiers. But to give a flavor of the enterprise, we present a partial analysis. We begin with the first tier's behaviors. In behavior (1) the teacher verbally presents material to define the domain of the exercise. Behaviors (3) and (4) are children's answers to the teacher's question. Behavior (5) is the teacher's response to the children's answers, acknowledging that the answers were correct.

As mentioned above, events are a series of triad interactions at the level of interactions between the teacher and the children. Generally the teacher asks a question, a child answers, and the teacher evaluates the answer. In the above interactions, we noted and classified 4 events.

The next unit in the first tier is episodes, which are comprised of a number of events. In the sample interaction we described above, the first episode is comprised of the 1, 2, 3, and 4 events and is labeled "Using Already-Learned Knowledge". The second episode is comprised of the first and second events. Here the teacher makes an initial attempt to move the children beyond the already-learned knowledge to find one rod that is the same length as the two rods that are placed side-by-side. This episode is labeled "Broadening Children's Arithmetic Operation".

At the level of the second tier, the meta-assumption of the first episode was that existing knowledge can be activated. The cognitive goal of the first events of that episode, was to

guide the children to mentally use arithmetic operations. The process this teacher believes that children perform to allow this cognitive goal is the identification of the appropriate arithmetic operations that exist as already-learned knowledge. The basic assumption this teacher has about the cognitive processes is the following: using rods as concrete material and demonstrating the results of putting two small rods together causes children to identify the appropriate already-learned arithmetic operations that exist in their minds.

Results

Content validity was checked and inter-rater reliability was very high (ranging between .95-1.00 for the various units) when independent judges scored the videotaped lessons at both tiers of analysis.

The findings were that teachers have an in-action mental model of children's minds and of how learning takes place in their minds. The in-action mental model is comprised of the units of the second tier and the relations among them. It is a top-down mental model. Teachers have meta-assumptions about children's learning, e.g., "children can generalize". These lead to assumptions, which connect teaching to cognitive processes, e.g., a verbal summary (which is the teaching part) enables children to generalize (which is a cognitive process). These cognitive processes lead to the attainment of a cognitive goal, e.g., "to generalize a specific arithmetic operation".

We argue that the in-action mental model is the psychological entity that gives rise to the teaching behaviors we saw in the units of the first tier. In other words, this in-action mental model directs teachers' teaching.

We also found that although there were differences between the 3 groups of teachers, there was no consistency in the way they differed. In other words, there was no progression regarding the expression of the various aspects of the units within the in-action mental model per teaching experience. The differences we found were connected to the frequency with which the aspects of the elements of the model occurred, and the time teachers devoted to them.

Discussion

The teachers' in-action mental model of children's minds and learning that we uncovered by analyzing teachers' teaching is implicit and intuitive, and reflects a common sense understanding of the mind. Interestingly, teachers from all three groups have the same mental model.

This in-action model gives expression to professional thinking and to the richness and complexity of what occurred in the course of a lesson. The dynamic and complex situation of teaching is difficult to "freeze" and represent in a way that shows its dynamic aspects. Nevertheless, the in-action mental model we present, attempts to describe the dynamic and multi-faceted nature of teaching.

Educational Implications

This model has several implications for teacher education:

- First, the in-action mental model we discovered amongst teachers (preservice, novice and experienced) has a profound influence on how they teach. We argue that the in-action mental model teachers have of children's minds and learning gives rise to their instruction.
- Second, preservice and inservice teachers understand what is being taught in courses and workshops that relate to children's learning, via their in-action mental model. Research in the cognitive sciences (Clement, 1982; diSessa, 1982) shows that mental models are cognitive entities that transform instruction. When we teach some subject matter, it gets changed by the mental model students have constructed. Therefore These mental models are also resistant to change. The mental model we discovered comes to influence how teachers learn about learning.
- Third, teachers are not aware they hold this model, let alone its complexity and richness. In order for the implicit in-action mental model to be discussed, it must become explicit. Part of teacher education, then, could attempt to help teachers become aware of their implicit in-action mental models that, we believe, govern how they teach. This could be achieved, in part, through stimulated recall.

- Fourth, the tool we developed to describe teachers' in-action mental models of children's minds and learning can be used in teacher education both as a diagnostic tool and as a tool for instruction. Vygotsky (1978) noted how one can both assess and instruct at the same time, where each of these processes helps, through scaffold dialogue, to enrich the other.

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